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ADVANCED TESTING TECHNOLOGY RDT AND E PROGRAM. REVISION 1.(U)
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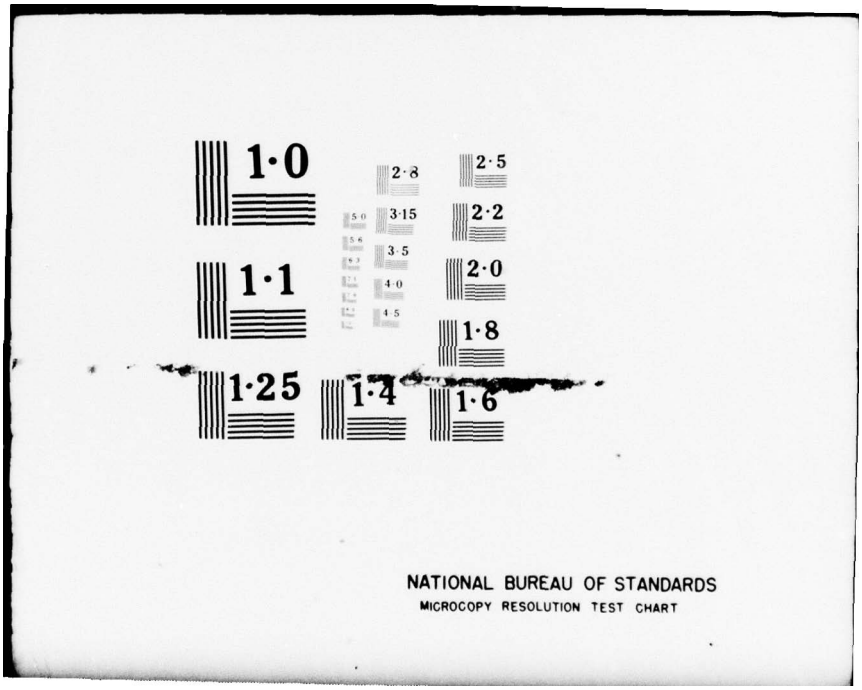
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RESEARCH

DAVEX

MANAGEMENT

ADVANCED TESTING TECHNOLOGY

RDT&E PROGRAM

Modification No. 1

1 August 1977

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Office of Naval Research
Arlington, Virginia 22217

DAVEX ENGINEERING COMPANY
Sorrento R & D Center
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San Diego, California 92121

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AUTOMATIC TEST EQUIPMENT

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A modification to the Navy-wide RDT&E Program Plan in Advanced Testing Technology is set forth which calls for an additional expenditure of $187,010,000 over a five year period. Projects recommended to be undertaken are outlined in the areas of ATE software; automatic test program generation; propulsion, electrical and auxiliary machinery; advanced ATE; design for testability; and education, training and management.

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RESEARCH

DAVEX

MANAGEMENT

ADVANCED TESTING TECHNOLOGY

RDT&E PROGRAM

Modification No. 1

1 August 1977

Prepared by: David M. Goodman

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ADVANCED TESTING TECHNOLOGY RDT&E PROGRAM

I. INTRODUCTION

The Navy RDT&E Program in Advanced Testing Technology prepared by MAT 04T in October 1976 is recommended for modification as set forth herein.

The October 1976 program recommended a five year expenditure of $142,560,000. This report* recommends an additional expenditure of $187,010,000.

For those who question the need for a program of this magnitude, reference is made to the selected comments reproduced in Appendix A of the October 1976 report.

To confirm that the need for this program is as strong as ever, there is attached to this report (also Appendix A) statements which reflect recent judgments of Senator Dale Bumpers of Arkansas, Senator John Culver of Iowa, and General David Jones of USAF.

More detailed support for this RDT&E program was provided on 15-16 June 1977 at the DOD/Industry Meeting of Automatic Testing in Arlington, Virginia. The recommendations of industry were formally presented at this meeting, and on July 1, 1977 to Admiral Michaelis, Chief, NAVMAT. The numerous industry recommendations have been given due consideration and in many instances have been incorporated into this report.

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* This report should be read in conjunction with the October 1976 publication. A dual page numbering system has been used so that this document may be retained in its present form or so that the pages may be separated and inserted into the basic document.

1. ATE SOFTWARE

V.I.2.a ANALOG TEST PROGRAM GENERATION

TASK DESCRIPTION:

Investigate and develop methods for preparing step-by-step procedures for performing end-to-end and diagnostic tests on analog electronic systems including receivers, transmitters, antennas, and displays as typically are used in communications, navigation, command and control, and electronic warfare.

TECHNICAL APPROACH:

Task 1 - Several parallel study contracts will be initiated to define different theoretical approaches for automatically generating analog test programs for different classes of components, circuits, and equipment embracing the full radio frequency spectrum. These studies will extend form DC to microwaves but with particular emphasis on communications systems and sub-systems in VLF, LF, HF. VHF. UHF & SHF using single sideband, and phase and frequency modulation.

Task 2 - The results of Task 1 will be coupled with a survey of the literature and commercial products. Results being achieved on the Total Ship Test Program (TSTP) now in progress for shipboard external communications systems will be evaluated. From these investigations, test systems will be developed to meet the requirements both shipboard and and depot testing.

PRIORITY: First SPONSOR: ONR,NAVAIR,NAVELEX

DELIVERABLES:

Annual Technical Reports	FY78-80
Prototype Demonstrations	FY79-80
Technology Assessment Reports	FY79-83
Shipboard and Depot Applications	FY80-83

COST:		FY78	FY79	FY80	FY81	FY82
Task 1	6.1	150K	150K	150K	100K	50K
	6.2	100K	150K	150K	100K	50K
Task 2	6.3		300K	600K	500K	400K
	6.4			1,000K	3,000K	5,000K

1. ATE SOFTWARE

V.1.2.b GLOSSARY OF TERMS FOR ATPG

TASK DESCRIPTION:

Compile, up-date, and maintain a dictionary of terms used in automatic test program generation, analog and digital. Prepare a MIL-STD with the cooperation of other DOD components and industry.

TECHNICAL APPROACH:

The procedure followed in preparing MIL-STD 1309 (Definition of Terms for Test, Measurement, and Diagnostic Equipment) should be emulated and improved upon in generating this ATPG glossary of terms.

PRIORITY: Second SPONSOR: NAVAIR,NAVELEX,NAVSEA

DELIVERABLES:

Prelininary MIL-STD	FY79
Coordinated MIL-STD	FY80, 82, 84

COST:

	FY78	FY79	FY80	FY81	FY82
6.2	40K	50K	50K	30K	30K

1. ATE SOFTWARE

V.1.14 ATE SOFTWARE CENTERS

TASK DESCRIPTION:

Establish pilot software centers for each of the three System Commands. Staff these centers with professionals for analysis, consultation, recommendation, and problem solving on matters primarily involving ATE software.

TECHNICAL APPROACH:

The lack of authentic base-line data with respect to most aspects of software design, verification, application, and modification continues to hinder the cost-effective utilization of ATE systems in the DOD environment. The people and data needed to properly manage this technology are widely dispersed. This task will be to track the state-of-the-art in ATE software by bringing together a small group of professionals in each of the three System Commands who will concentrate on the following problem areas;

Life Cycle Cost Drivers for Test Program Sets (TPS)
Requirements for Diagnostic Test Depths
Documentation and Change Control
Field-data Acquisition and Feedback Methods
Simulation and Standardization of ATE and UUT
Operator Interface and Record-keeping
Work-load and Throughput Statistics

To assist in performing the above functions, each of the three software centers will develop and maintain its own Software Data Bank. The function and format of the data banks will be coordinated through the Testing Technology Center for uniformity, utility, and cost control.

PRIORITY: Urgent SPONSORS: NAVAIR,NAVELEX,NAVSEA

DELIVERABLES:

Annual Technical Reports FY78-92

COST:		FY78	FY79	FY80	FY81	FY82
6.5	NAVAIR	300K	400K	500K	500K	500K
	NAVELEX	200K	250K	300K	400K	500K
	NAVSEA	100K	200K	300K	400K	500K

1. ATE SOFTWARE

V.1.15 R&D TO SUPPORT ATE SOFTWARE CENTERS

TASK DESCRIPTION:

Conduct basic research into non-numeric large data and graphic file management systems to supplement the limited interactive capability available in contemporary computer systems.

TECHNICAL APPROACH:

The specific purpose of this research is to assist the development of the three ATE Software Centers by eventually providing better means for collecting, processing, interpreting, distributing, and utilizing the large volumes of data and imformation which are inherent in the operation of these centers. This task may also yield results of value to other ATE Information Centers. The preferred technical approach is not known at this time.

PRIORITY: First SPONSOR: ONR, NAVAIR

DELIVERABLES:

Annual Technical Reports FY78-82

COST:

	FY78	FY79	FY80	FY81	FY82
6.1	50K	75K	100K	100K	100K
6.2			100K	200K	300K

2. PROPULSION, ELECTRICAL, & AUXILIARY MACHINERY

DELIVERABLES:

Sensor Trade-Off Analysis Report	FY78
Sensor Techniques Development Report	FY78
Prototype Implementation Report	FY79
Test and Evaluation Report	FY80
Additional Sensor Development	FY81

COST:

	FY78	FY79	FY80	FY81	FY82
6.2	100K	100K	100K	100K	100K
6.3		300K	400K	300K	300K
6.4			1,000K	1,000K	1,000K

2. PROPULSION, ELECTRICAL, & AUXILIARY MACHINERY

V.2.1.a CONDITION MONITORING MODULES

TASK DESCRIPTION:

Develop a family of standard condition monitoring modules, and prepare general guidelines and detailed specifications for their use, to enable the systematic installation of on-line automatic test equipment on different types of propulsion and auxiliary machinery machinery in all the ships of the fleet commencing in 1985.

TECHNICAL APPROACH:

The technology being developed in other parts of this Advanced Testing Technology program will be tracked and assessed in the initial phase of this project. Particular emphasis will be placed on reviewing the NAVAIR projects relating to test and diagnostics for propulsion and machinery equipment, and the NAVSEA project on the evaluation of the LM-2500, FT-9, and LST 1179 class of ships.

For new equipment, existing sensor technology will be identified which can be designed into the machinery to be monitored. In addition "strap-on" sensors will be developed which will permit attachment to equipment which does not contain its own internal sensors.

Other condition monitoring modules will be developed for data transmission, processing, display, and record-keeping. These modules will also be capable of interfacing with other ship systems such as SMDS which may be installed for communication and test purposes. Guidelines and specifications will be prepared to influence, control, and assist in the management of this long-range project.

PRIORITY: Second SPONSOR: NAVSEA

DELIVERABLES:

Annual Technical Reports	FY78-82
Prototype Models, initial	FY81
Prototype Models, continuing	FY82
Initial Guidelines and Specifications	FY82

COST:	FY78	FY79	FY80	FY81	FY82
6.3	150K	150K	600K	3,000K	5,000K
6.4					5,000K

2. PROPULSION, ELECTRICAL, & AUXILIARY MACHINERY

V.2.1.b CONDITION MONITORING FOR SHIP PROPULSION MACHINERY

TASK DESCRIPTION:

Perform land-based and sea-test evaluations of the existing LM-2500 Condition Monitoring System and the FT-9 Engine-Condition Monitor. Implement recommendations of prior feasability study on a Diesel Engine Condition-Monitoring System for the LST 1179 class.

TECHNICAL APPROACH:

The first two prototype monitoring and diagnostic and diagnostic systems for naval ship propulsion machinery were designed for the LM-2500 and FT-9. A different approach was set forth in a feasability study for the Deisel class of main propulsion machinery. These efforts will be continued (and coordinated) to verify and quantify the benefits derived from reduced maintanance manning, lesser repair costs, and increased availability of the entire ship platform. Approximately $1,500K-2,500K have been invested in the LM-2500 and FT-9 Engine-Condition Monitors. Relying on the experience gained, the development cost for the LST 1179 class is estimated at $500K over three years. This project will be directed towards evaluating the findings on the two prototype systems so that these results can be factored into the Diesel Engine Monitor and other subsequent programs.

PRIORITY: First SPONSOR: NAVSEA

DELIVERABLES:

Evaluation Report LM-2500	FY79
Evaluation Report FT-9	FY79
Preliminary Design LST-1179	FY79
Prototype Installation LST-1179	FY80
Prototype Evaluation	FY81
Specification for Condition-Monitors	FY82

COST:	FY78	FY79	FY80	FY81	FY82
6.2	150K	150K	150K	150K	150K
6.3		250K	250K	250K	250K

2. PROPULSION, ELECTRICAL, & AUXILIARY MACHINERY

V.2.6 MEASUREMENT AND RECORDING SYSTEM DEVELOPMENT FOR ON-LINE MACHINERY MONITORING

TASK DESCRIPTION:

Explore dramatically new techniques for on-machine instrumentation and recording systems for ship propulsion and auxiliary machinery to better monitor critical parameters on drive shafting; camshaft and drive gears; governor and controls; and fuel, lube oil, and air systems.

TECHNICAL APPROACH:

This project focuses on novel measurement and recording techniques for ship machinery instrumentation. Development of a ship machinery-monitoring capability involves the prior analysis and testing of shipboard machinery to determine typical failure modes. Work now being performed by others in this area must be evaluated to assess the effectiveness of various detection, diagnosis, and prognosis techniques. On-machine instrumentation techniques will be devised to better acquire and record critical operational parameters (or effects) for the machinery under test. The test components ultimately must be easily attached to the machinery under test; and must operate unattended for long periods of time in a shipboard environment. New solutions to meet these long-standing requirements will be sought.

DELIVERABLES:

Feasibility Study Report	FY78
Annual Technical Reports	FY78-82

COST:	FY77	FY78	FY79	FY80	FY81	FY82
6.2	50K	100K	100K	150K	125K	125K

2. PROPULSION, ELECTRICAL, & AUXILIARY MACHINERY

V.2.8 ATE FOR SHIPS ELECTRICAL POWER

TASK DESCRIPTION:

Develop improved means for automatically monitoring and recording the steady-state and transient output of primary and secondary electrical power sources aboard surface ships. Develop improved means for monitoring the turbines, mechanical drive trains, and electrical generators to reduce manning and maintenance requirements.

TECHNICAL APPROACH:

Many of the newer equipments being installed aboard ships contain semi-conductor components which are sensitive to transient spikes in the electrical power system. Protective dircuitry cannot be depended upon to always withstand these transients, and equipment function can be degraded even if hard faulures are not induced. This project will review the results being achieved in the commercial electrical power industry, and in aircraft electrical systems, in order to determine to what extent and by what means the electrical power on surface ships will be best conditioned. Consideration will be given to additional factors which may be peculiar to a ship-board environment such as grounding, EMI, lightning strikes, and damage control. A prototype system will be developed utilizing currently available technology to demonstrate and clarify the requirements for electrical power conditioning, monitoring, and record keeping. The effect of irregularities in the drive system on the ships electrical output will be determined.

PRIORITY: First SPONSOR: NAVSEA

DELIVERABLES:

Annual Technical Reports	FY78-82
Interim Recommendations	FY79
Prototype Installation	FY80
Evaluation of Prototype, Land	FY81
Evaluation of Prototype, Sea	FY82

COST:	FY78	FY79	FY80	FY81	FY82
6.3	150K	250K	1,000K	2,000K	500K

4. ADVANCED AUTOMATED TESTING (CONCEPTS & HARDWARE)

V.4.1 NEW TEST TECHNIQUES (FOR END-ITEMS)

TASK DESCRIPTION:

Investigate and develop new and improved test techniques for end-items to reduce test times and to improve the quality of testing. Concentrate on classes of end-items known to present difficult testing problems.

TECHNICAL APPROACH:

This project will consist of several parallel but coordinated tasks in which the basic theories of operation will be analyzed in an effort to originate new and effective test procedures for each of the following classes of end-items.

1. Phased-Array Antenna (radar and sonar)
2. Doppler Radar
3. Closed-Loop Feedback Systems
4. Microwave Strip-Line Circuitry

PRIORITY: First SPONSOR: ONR

DELIVERABLES:

Annual Technical Reports FY78-82

COST:

	FY78	FY79	FY80	FY81	FY82
6.1	500K	1,000K	1,000K	1,000K	1,000K

4. ADVANCED TEST TECHNIQUES (CONCEPTS & HARDWARE)

V.4.1.a NEW TEST TECHNIQUES (FOR ATE SYSTEMS)

TASK DESCRIPTION:

Anticipate new test requirements for ATE systems generated by the incorporation of the emerging technologies into prime system development programs. Investigate all advances in technology to determine applicability to new ATE system design.

TECHNICAL APPROACH:

This project will consist of several tasks. Although the stress will be on the sewer technologies, investigations will also be made into finding new solutions for older previously identified problems, in calibration and switching. The several task areas are:

1. Self-Test and Calibration
2. Analysis of Errors Introduced by Signal Sampling and/or Data-Bus Communication
3. Signal Sampling by Scan Converters
4. Programmable Interfacing
5. Multiple-Switch Status and Performance Sensing
6. Front-End and Distributed Microprocessors
7. Data Transmission Over 40mHz
8. Fiber Optic Data Transmission
9. Fiber Optic/Charge-Coupled-Device Interface.
10. Optical Switching

PRIORITY: First SPONSOR: ONR , NAVELEX,NAVAIR,NAVSEA

DELIVERABLES:

Annual Technical Reports	FY78-82
Feasability Prototypes	FY79-82

COST:

	FY78	FY79	FY80	FY81	FY82
6.2	1,000K	2,000K	3,000K	3,000K	4,000K

4. ADVANCED TEST TECHNIQUES (CONCEPTS & HARDWARE)

V.4.1.b LANGUAGE-DRIVEN FUNCTIONAL ATE

TASK DESCRIPTION:

Investigate the feasability of generating a new programming language to guide and control the design of ATE hardware.

TECHNICAL APPROACH:

Task 1. This study will be directed towards reversing the sequence of ATE system design so that the software and language elements will be structured first to be then followed by the hardware design. ATLAS, BASIC, and OPAL will be reviewed as will other languages and other software packages. This task is a new start. The best method of approach will be solicited.

Task 2. This study will be directed specifically towards the use of graphical and pictorial programming aids, as contrasted to the alpha-numeric data handling format in current useage in ATE software systems.

PRIORITY: Second SPONSOR: ONR

DELIVERABLES:

Annual Technical Reports FY78-82

COST:

6.1	FY78	FY79	FY80	FY81	FY82
Task 1. ATE Graphics	350K	350K	350K	350K	350K
Task 2. Language Design	350K	350K	350K	350K	350K

4. ADVANCED TEST TECHNIQUES (CONCEPTS & HARDWARE)

V.4.1.c ATE MAN-MACHINE INTERFACE

TASK DESCRIPTION:

Research the theoretical and practical aspects of improving the operator-ATE interface. Identify and evaluate the basic parameters in the ATE man-machine interface. Apply the results obtained to several related but different ATE applications.

TECHNICAL APPROACH:

This study will be approached on the basis that human interpretation of ATE derived data can be much improved if the data content and data format is better presented. Participants in this study will include maintenance engineers, display experts, ATE programmers, and human-factors/human-engineering people. Areas fo investigation will include communications efficiency, causes of operator confusion and error, guidance for test program designers, etc. Results of this study will be applied to the following problem areas;

1. Test Program Set (Design and Utilization)
2. Distortion, Intermittent-Fault, and Multiple Fault Analysis
3. Complex Digital Pattern Analysis
4. Multiple Profile Data Correlation
5. Automated Maintenance Action Logging

PRIORITY: First SPONSOP: ONR, NAVELEX,NAVAIR,NAVSEA

DELIVERABLES:

Annual Technical Reports FY78-82

COST:

	FY78	FY79	FY80	FY81	FY82
6.1	500K	700K	900K	900K	900K
6.2		500K	1,000K	2,000K	2,000K

4. ADVANCED TEST TECHNIQUES (CONCEPTS & HARDWARE)

V.4.1.d INFORMATION PROCESSING FOR ATE

TASK DEXCRIPTION:

Investigate entirely new approaches to the collection, organization storage, retrieval, interpretation, and distribution of large, complicated, and diverse data files such as are encountered in ATE hardware, software, and interface technology.

TECHNICAL APPROACH:

This is a new start. The preferred method of approach is not known. However, recent work in artificial intelligence, robotics, and pattern recognition will be reviewed in a search for promising lines of inquiry.

PRIORITY: Second SPONSOR: ONR

DELIVERABLES:

Annual Technical Reports FY78-82

COST:

	FY78	FY79	FY80	FY81	FY82
6.1	65K	75K	75K	75K	75K
6.2		75K	150K	150K	150K

4. ADVANCED TEST TECHNIQUES (CONCEPTS & HARDWARE)

V.4.1.e ATE BUILDING-BLOCK AUGMENTATION

TASK DESCRIPTION:

Fill in the gaps in the present inventory of ATE building blocks, and enhance the standardization therof.

TECHNICAL APPROACH:

Following a study and definition phase, protptype building blocks will be developed. Close coordination will be maintained with the SEM program. Candidates for thsi project are:

1. Family of Power Supplies
2. Family of Switching Modules
3. Microwave synthesizer, 18-100gHz
4. Mass-Memory Testers
5. Logic Analyzers
6. Operator Control and Display Station
7. High Power Test Station
8. Ruggedization of Selected Commercial Items

PRIORITY: Second SPONSORS: NAVAIR,NAVELEX,NAVSEA

DELIVERABLES:

Study reports	FY78-82
Definition of Building Blocks	FY79
Prototype of Building Blocks	FY80-82

COST:

	FY78	FY79	FY80	FY81	FY82
6.3	1,500K	1,500K	10,000K	10,000K	10,000K

4. ADVANCED TEST TECHNIQUES (CONCEPTS & HARDWARE)

V.4.1.f SEM FOR ATE

TASK DESCRIPTION:

Develop a family of Standard Electronic Modules (SEM) for both off-line and on-line ATE.

TECHNICAL APPROACH:

The SEM hardware program has been making progress for many years in several different parts of Navy. The SEM program has been directed primarily at prime equipment. Approximately 3,000,000 SEM's are operating in Fleet weapons systems. These SEMs are also finding useage in ground support equipment. The purpose of this ATE project will be to build upon and expand the present SEM efforts. The first step will be to identify all SEM in the inventory and those items scheduled to be added. The possibility of using this SEM hareware as building blocks for future ATE systems will be investigated. If the results of this inquiry are positive, then the requirements for additional SEM building blocks will be delineated. The time and cost of developing these SEM's will be projected and compared to conventional hardware acquisition. It is anticipated that the results of these studies will be extremely favorable for the SEM approach. The end result can be a standardized approach to the "instrument-on-a card" concept which has already achieved some success in other instrumentation systems.

PRIORITY: First

SPONSORS: NAVELEX,NAVSEA

DELIVERABLES:

SEM Catalog for ATE	FY78
Feasability Report	FY78
SEM Augmentation	FY79-82
Prototype ATE	FY80-82

COST:

	FY78	FY79	FY80	FY81	FY82
6.2	75K	50K			
6.3		350K	500K	500K	500K
6.4			1,000K	3,000K	5,000K

4. ADVANCED TEST TECHNIQUES (CONCEPTS & HARDWARE)

V.4.1.g NEXT-FAMILY OF OFF-LINE ATE

TASK DESCRIPTION:

Define and develop a complete family of off-line ATE to better meet future needs.

TECHNICAL APPROACH:

The definition phase of this project will concentrate on building block characteristics, data bus protocols, and switching modules in different functional groupings. Navy test requirements will be analyzed in terms of spectrum, density, and site location. WRA/SRA test correlation requirements will be set forth in terms of error cones and tolerance trees. Original or source test data, languages, compilers, and documentation methods will be investigated including their interplay with BIT/SCT provisions of the future. Logistics support and product improvement factors will be considered such as operator and maintenance training, calibration and repair, and test equipment obsolescence. A plurality of prototype building blocks, and a partial operating system, will be constructed using off-the shelf test equipment where applicable. Specifications and documentation will be prepared for quantity procurements.

PRIORITY: First SPONSORS: NAVAIR,NAVELEX,NAVSEA

DELIVERABLES:

Definition of AEE, Annual Reports	FY79-82
Building Blocks, Prototypes	FY80-82
Operating System	FY81
Specifications	FY81-82

COST:

	FY78	FY79	FY80	FY81	FY82
6.2	450K	450K	450K	450K	450K
6.3		3,000K	7,000K	15,000K	25,000K

5. DESIGN FOR TESTABILITY

V.5.0 BIT/SCT COMPENDIUM

TASK DESCRIPTION:

Classify BIT/SCT design techniques that have proven successful over the years in their application to systems, sub-systems, and component test and evaluation. Develop a framework for evaluating the cost/benefit ratio of these successful applications. Identify new candidates for the application of BIT/SCT, hardware and software.

TECHNICAL APPROACH:

The literature abounds with examples of good and bad BIT/SCT. An assessment of this technology will be made to identify the causes and costs of success and failure. A compendium will be prepared which will include a description of the technology and management initiatives applied by Navy to the Modular Radar Program, the SEM program, the Fleet Ballistic Missile program, the F-4, F-14, E-2c, etc. From this assessment, recommendations will be made as to preferred design practice for new systems. Further R&D efforts needed to maintain an adequate technical capability in BIT/SCT will be identified on a continuing basis.

PRIORITY: First SPONSOR: ONR/TTC

DELIVERABLES:

Annual Technical Reports FY79-82

COST:

	FY78	FY79	FY80	FY81	FY82
6.2	300K	400K	500K	400K	300K

5. DESIGN FOR TESTABILITY

V.5.0.a BIT/SCT PAYOFF DEMONSTRATION

TASK DESCRIPTION:

Perform a real-life case study to identify the factors which impede the application of BIT/SCT to modern sophisticated electronic systems. Estimate the hardware and software investment that is needed to satisfy the requirements for an optimally designed BIT. Conduct this study on a system which may be modified to actually benefit from the analysis. Draw general conclusions to affect management decisions on future acquisitions such as VSTOL.

TECHNICAL APPLICATION:

A preferred candidate for this study has been identified as the AN/AWG-10,10A fire-control system used in the Navy F-4 aircraft. Alternate candidates are the Terrier and Tartar shipboard radar systems AN/SPG51,55. The above systems are widely deployed in the Fleet and are known to have persistent, chronic maintenance problems. Discussions will be re-opened with respect to the AWG 10,10A where preliminary planning has indicated a good probability for success. The study is intended to have practical application in the future modification of several hundred AN/AWG-10.

PRIORITY: First SPONSOR: TTC/NAVAIR

DELIVERABLES:

BIT Hardware/Software Definition	FY77
Case Study Report	FY78
BIT Augmentation & Evaluation	FY79
Management Report	FY79

COST:

	FY77	FY78	FY79	FY80	FY81	FY82
6.2	30K	100K	100K	50K		
6.3		650K	3,000K	2,000K		
6.4				TBD	TBD	TBD

5. DESIGN FOR TESTABILITY

V.5.6 TESTABILITY IN FAULT TOLERANT DESIGNS

TASK DESCRIPTIONS:

1. Prepare a technology assessment report covering fault tolerant hardware and software. Based upon this assessement, identify the contemporary principal approaches for implementing fault tolerance. Identify the maintainability requirements for each appraoch. Using this information as base-line, investigate and develop a methodology for the design of maintainable and testable fault tolerant systems.

2. Compile a dictionary of terms for fault tolerance compatible with MIL-STD 1309B for Automatic Test Equipment.

3. Concuct basic research into new and improved techniques for describing, designing, and implementing fault tolerant systems; and for testing these systems to determine their operational and maintenance status.

4. Conduct research into better methods of communicating (and documenting) ideas and information in fault tolerant technology.

TECHNICAL APPROACH:

Task 1. Identify, catagorize, and describe the principal techniques now used for implementing fault tolerance by review of the world-wide literature in the field; by review of contemporary fault tolerant equipment designs; and by review of ongoing research and development projects at ONR, NSF, NASA, AF, industry, and elsewhere.

Task 2. Identify the language, and more precisely define all the key terms, in common useage in fault tolerance theory and practice. This effort will build upon the results of previous incomplete actions by the IEEE and other professional groups.

Task 3. Conduct independent studies on the following classes of technology treated as separate but related entities;

a. Computers
b. Communications
c. Control Systems
d. Distributed Microprocessor Systems

Preference will be given to individuals to conduct these studies where the research direction is different from that which has been pursued in the past in order to encourate novel approaches and to extend the technology base of competent professionals. Close coordination of these studies, between each of them and with the hardware/software technology assessment described above, is to be effected by staff of ONR and TTC.

Task 4. Research will be conducted into graphical, pictorial, and alpha-numeric methods of information transfer and documentation relative to this specific technology. Techniques common to graph theoretics and pattern recognition will be examined.

DELIVERABLES:

Annual Technical Reports	FY78-82
Technology Assessment Report	FY79
Methodology for Design and Test	FY80
Dictionary of Termsm Preliminary	FY81
Dictionary of Terms	FY81

6.1 Tasks	FY78	FY79	FY80	FY81	FY82
Computers	75K	75K	75K	75K	75K
Communications	75K	75K	75K	75K	75K
Control Systems	75K	75K	75K	75K	75K
Distributed uPs	75K	75K	75K	75K	75K
Information/Graphics	75K	75K	75K	75K	75K
	375K	375K	375K	375K	375K
6.2 Tasks					
Technical Assessment	100K	100K	75K	75K	75K
Design Methodology			100K	100K	100K
	100K	100K	175K	175K	175K

6. EDUCATION, TRAINING, & MANAGEMENT

V.6.10 MAINTENANCE SHOP MANAGEMENT

TASK DESCRIPTION:

Conduct a study of current maintenance-shop practices to identify and expand the use fo those practices that contribute to high productivity. Translate these findings into more widespread use.

TECHNICAL APPROACH:

There is considerabel diversity in the test and repair cycles being practiced in the various Navy maintenance activities. It is an established fact that certain maintenance sites characteristically have amuch higher work output in terms of repaired and test certified components than do other sites, this in spite of the fact that test equipment is similar, personnel staffing appears to be standard, and no marked differences exist in shop workload. This study will identify those practices that contribute to high productivity. From this study, improved shop management and scheduling procedures will be documented to accelerate their use at the low production sites. This study will include all of the shop sub-systems that need improvement to achieve optimum ATE utilization.

PRIORITY: First SPONSOR: NAVMAT/NAVAIR

DELIVERABLES:

Shop Management Findings	FY78
Shop Management Procedures, Interim	FY79
Shop Management Procedures, Final	FY80

COST:

	FY78	FY79	FY80	FY81	FY82
6.5	850K	850K	650K	250K	250K

6. EDUCATION, TRAINING, & MANAGEMENT

V.6.11 ATE BASE-LINE PRODUCTIVITY

TASK DESCRIPTION:

Collect authoritative data and develop pertinent statistics on ATE thruput for state-of-the-art Navy ATE systems in a high work-load environment. Present this information in a format which will facilitate comparison with other ATE systems.

TECHNICAL APPROACH:

This effort is in the nature of a "time and motion" study but directed to measuring overall productivity, or thruput, in contrast to making observations on individual actions in a complex electronics maintenance activity. Two ATE systems which are roughly equivalent in sophistication will be selected. Candidates initially selected are VAST and AN/AWM-23. These testers operate in the same avionics environment, with similar work-loads; Navy technicians and contractor support; and are derived from the same electronics era. These testers are widely deployed in the Navy and are of a mature design. The information derived from this study will fill a large gap in the understanding of ATE productivity, and will assist management in planning for the future.

PRIORITY: First SPONSOR: TTC

DELIVERABLES:

Interim Report	FY77
Final Report	FY78

COST:

	FY77	FY78	Fy79	FY80	FY81	FY82
6.5	35K	85K				

6. EDUCATION, TRAINING, & MANAGEMENT

V.6.12 ACQUISITION MANAGERS-ATE INDOCTRINATION COURSE

TASK DESCRIPTION:

Develop a new course of instruction, or augment an existing course, to indoctrinate Navy acquisition managers and their respective staffs in the different actions that need to be taken to procure ATE in a more timely and more cost-effective manner.

TECHNICAL APPROACH:

One-day seminars will be developed to familiarize Navy officers with the functions, capabilities, and limitations of each of the organizational groups involved in the Navy ATE effort. The presentation will review the DSARC cycles and relate these cycles to organizational decision makers. The presenter should be a management-level person with a good overview of the total ATE scene. Seminar attendees should be Navy personnel in (or soon to be in) management postions.

PRIORITY: First SPONSOR: NAVMAT

SELIVERABLES:

Seminars-every two weeks FY77-82

COST:

	FY77	FY78	FY79	FY80	FY81	FY82
6.5	100K	75K	50K	50K	50K	50K

6. EDUCATION, TRAINING, & MANAGEMENT

V.6.13 ACQUISITION MANAGERS-ATE TECHNOLOGY COURSE

TASK DESCRIPTION:

Develop a technology intensive course of instruction for key personnel assigned to each major acquisition manager to review the state-of-the-art in ATE. Use selected examples to provide an in-depth refresher of the core technologies contained in most ATE.

TECHNICAL APPROACH:

This course will review the many technology-based aspects of ATE including hardware, software, and interfacing for both on-line and off-line devices. Attendees will become more familiar with ATE, and will simultaneously receive a general technology up-date, but this course will stress the fact that more detailed assistance will be needed for making decisisns on a case-by-case basis. Sources of expertise resident in Navy, and elsewhere, will be identified. This course will be scheduled in two parts, two weeks of instruction total. One week will be devoted to on-line ATE: one week to off-line. Both parts will include software instruction.

PRIORITY: First SPONSOR: NAVMAT

DELIVERABLES:

Courses of Instruction	FY78-82

COST:

FY78	FY79	FY80	FY81	FY82
100K	75K	75K	75K	75K

6. EDUCATION, TRAINING, & MANAGEMENT

V.6.14 SUPPORT FOR NAVY ATE STRATEGY GROUP

TASK DESCRIPTION:

Bring together the expertise residing in all the NAVMAT laboratories and elsewhere in Navy to support, strengthen, manage, and execute the Navy-wide RDT&E Program in Advanced Testing Technology.

TECHNICAL APPROACH:

To be determined. This is a new start. Coordination and central leadership will be provided by the Navy Testing Technology Center at NOSC. Strong administrative and managerial support will be provided by the TAMS Program Office in NAVMAT.

PRIORITY: Urgent SPONSOR: NAVMAT

DELIVERABLES:

Annual RDT&E Program in ATE FY78-82

COST:

	FY78	FY79	FY80	FY81	FY82
6.5	250K	250K	250K	250K	250K

6. EDUCATION, TRAINING, & MANAGEMENT

V.6.15 ATE TECHNOLOGY CENTER FOR R&D

TASK DESCRIPTION:

Establish a Navy managed semi-independent, professional, ATE center to help coordinate and evaluate the many diverse but related projects and tasks set forth in the Advanced Testing Technology (ATT) RDT&E Program.

TECHNICAL APPROACH:

The basic foundation of the ATT program is technology. Because the newer technologies yield the promise of greater pay-off, a Technology Assessment and Forecasting Function will be established. The professional staff of this central ATE Center will support and be supported by the activities of the Navy-wide ATE Strategy Planning Group. As the expertise of the staff grows. they will also provide the functions of analysis, consultation, recommendation , and problem solving in an objective and semi-autonomous mode.

An R&D information storage and retrieval system will be designed and maintained by the professional staff in order to provide rapid access to the many volumes of significant scientific and engineering data that is being generated in this ATE technology. This data will also be made available to others. Coordination and leadership will be provided to enhance the quality, compatability, and efficiency of information transfer within and between all Navy ATE Data Banks.

PRIORITY: Urgent SPONSOR: NAVMAT/TTC

DELIVERABLES:

Annual Technical Reports	FY78-82,...
Intermittent Technical Reports	FY78-82,...

Cost:

	FY78	FY79	FY80	FY81	FY82
6.5	650K	650K	650K	650K	650K

APPENDIX A

CONTINUATION OF SELECTED COMMENTS ON READINESS

1. Letter to Secretary of Defense, Harold Brown, with accompanying letter of Senator John Culver to Senator John Stennis dated March 29, 1977. Subject: "The Readiness Crisis".

2. Text of Senator Dale Bumpers as printed in the Congressional Record of April 6, 1977. Subject: "Military Readiness Crisis".

3. Message of approximately January 1976 from General David C. Jones, Chief of Staff, USAF to General Evans (AFSC/CC) and to General Rogers (AFLC/CC). Subject: ATE Development and Acquisition Management.

4. Reprint from NOSC Outlook, Vol. 1, No 8, June 3, 1977. Subject: *Comments of Norman Polmer, Editor*, 1966-1976 U.S. Navy Section, Janes Fighting Ships.

IOWA

United States Senate

WASHINGTON, D.C. 20510

Honorable Harold Brown
Secretary of Defense
The Pentagon
Washington, D. C.

Dear Secretary Brown:

Enclosed is a copy of my report for the Senate Armed Services Committee on the combat readiness of our Armed Forces. This was prepared as part of my continuing study of this important issue and draws upon on-site visits to a dozen military installations last December as well as additional information provided by the Services.

I hope that you will have an opportunity to read this report and that you will share with me your own reactions and suggestions, if you wish.

Sincerely,

John Culver

JOHN C. CULVER

JCC:cs
Enclosure

5627

United States Senate
COMMITTEE ON ARMED SERVICES
WASHINGTON, D.C. 20310

March 29, 1977

The Honorable John C. Stennis
Chairman
Senate Armed Services Committee
Washington, D.C. 20510

Dear Mr. Chairman:

Since joining the Senate Armed Services Committee, I have developed and pursued an interest in the actual combat readiness of our military forces. In hearings and Committee discussions, as well as in field inspections, I have endeavored to learn the facts, explore the problems, and suggest solutions which would improve our defense capabilities.

The Secretary of Defense and the Chairman of the Joint Chiefs of Staff provide our Committee, in their annual reports, with an overview of the readiness of our forces in broad outline. In recent years, the picture has been one of persistent and serious problems.

In order to study these important issues in greater detail, I traveled to a representative cross-section of a dozen military installations, covering all four Services, during the first week of December, 1976. A list of the places visited is attached.

On the basis of my visits, and after review of additional documentary materials subsequently provided to me, I have prepared the enclosed report, which addresses not only specific local situations but also the broader issues of readiness which are of great concern to our Committee.

Assisting me on this inspection trip were George Foster, the able and versatile Professional Staff Member of our Committee, Charles Stevenson of my staff, and Captain R. T. Manning, Navy escort officer. I deeply appreciate their efforts to make our necessarily brief visits informative and productive.

Sincerely,

JOHN C. CULVER

A-3/D-3

Alternatively, Melville gas could be piped 250 miles or so to the east coast of Bathurst Islands, near Freeman's Cove, and the liquefaction plant and terminal built there. This would require Class 7 icebreaking tankers, cheaper than the Class 10 ships required to get into southeast Melville all year round. Polar Gas is interested in the pipeline because it wants to prove its own water-crossing technology.

About three tankers would be needed, costing from $300 million to $500 million. The LNG plant and gathering system would cost more than $500 million.

Petro-Canada said in Ottawa the two studies should yield enough information for reports to be made to the National Energy Board and other government agencies by autumn. It promises all communities affected by the plan will be consulted.

MILITARY READINESS CRISIS

Mr. BUMPERS. Mr. President, my friend and colleague on the Armed Services Committee, Senator JOHN CULVER, of Iowa, recently made an important report to the committee on the combat readiness of our Armed Forces. Since joining the Armed Services Committee, Senator CULVER has done a major service by focusing on the question of combat readiness and suggesting ways to improve our actual defense capabilities. His latest report, based on an inspection trip to 12 military installations in December 1976, and a review of Defense Department documents, presents a serious picture of growing readiness deficiencies. This is a problem which should be of great concern to the Senate and also to the American taxpayers.

Senator CULVER found that we can rely on only a small fraction of our forces to be fully prepared for combat. On any given day, only about half of our aircraft and only half of our ships are operationally ready. On many planes, scarce parts are switched and reswitched for every flight. To reduce costs, training has been cut to a point which undermines the combat proficiency of our fighting units. We have also made foreign military sales of modern weaponry before filling the requirements of our own forces. And these problems adversely affect the morale of our service men and women, further aggravating shortages of the highly skilled personnel needed to operate our sophisticated military hardware.

Senator CULVER believes that it adds little to our defense to have exotic new planes, tanks, and ships on the drawing boards when large numbers of our current weapons are not fully operational today. He concludes that we should assign a higher priority to improved readiness so as to turn our existing forces into usable muscle. The Senator rightly says that when the American taxpayers are asked to spend over $123 billion a year on defense, they expect strong and capable forces, and they deserve the most cost-effective defense possible.

Mr. President, I recommend Senator CULVER'S readiness report for the attention of my colleagues. It is the latest of his contributions to the work of the Armed Services Committee and our efforts to provide a defense posture which protects the Nation's security at a cost commensurate with our other national priorities.

I ask unanimous consent that the Senator's report be printed in the RECORD.

There being no objection, the report was ordered to be printed in the RECORD, as follows:

THE READINESS CRISIS

America's military forces are in a shocking state of combat readiness. Despite billions of dollars spent on sophisticated new equipment, competitive pay and special bonuses, advanced training, and expanded funding for operations and maintenance, we can rely on only a small fraction of our forces to be fully prepared at any given time.

Personal on-site visits to operational units confirmed the deplorable figures already reported through the military chain of command and in annual reports to the Congress. In some cases, we found that local situations were even worse.

On any given day, only about half our combat aircraft are operationally ready to perform their missions. In the case of some expensive new systems, the figures for those planes that are fully capable drops as low as 10 percent.

Similarly, because of planned maintenance and unforeseen problems, only about half of our ships are operationally ready at any time.

In order to make our planes capable of performing their missions, parts are frequently taken from other aircraft and then returned afterward. For many planes, there is one instance of this switching and reswitching of parts for every sortie flown.

Maintenance personnel are often overworked and even discouraged from reenlisting by a cannibalization rate that wastes approximately 10 percent of all maintenance man-hours, with some personnel reporting that one-third to one-half their time is spent solely on juggling parts from one aircraft to another.

These problems have been getting worse rather than better in recent years. Since 1973 there has been a steady increase in the percentage of Navy aircraft grounded because of a lack of spare parts; the average last year was about 25 percent. The Air Force cannibalization rate has doubled in the past three years, and the even higher Navy rate is half again as high as in 1973.

Increasing costs have reduced training operations to the point that few soldiers, sailors, and airmen actually get to fire the weapons assigned to them, or with sufficient frequency to develop proficiency. In the mad dash to build up our mushrooming foreign military sales, we have not hesitated to furnish foreign powers with modern weaponry before meeting the needs of our own armed forces.

Shortages of trained personnel, excessive maintenance requirements, inadequate supplies of all spare parts, increasing costs—all of these factors have created a vicious cycle of reduced combat readiness and capability. The remedy for each specific problem only aggravates other problems.

In short, we do not have the ready military muscle to match our strength on paper. Consequently, U.S. taxpayers are not getting their money's worth from our hundred billion dollar plus defense budget.

We are wasting probable billions of dollars each year on unnecessary maintenance, caused by unreliable equipment.

We are straining the personnel system to its limits by proliferating advanced systems which require increased numbers of highly trained technical personnel.

We are rushing new programs into procurement when additional research, development, testing, and evaluation might have eliminated costly problems and when adequate consideration has not been given to the logistical demands which these new weapons create.

The solution to these problems is not simply to spend more money, although more funds are clearly needed for certain military activities. On the contrary, defense planners in recent years have frequently chosen to spend limited resources on new equipment and additional research rather than on current readiness. Yet the rush to modernization has occasionally exceeded a pace which would have produced greater reliability and lower life cycle costs.

We have been so caught up in the glamour of new technology that we have neglected our forces in being. Our preoccupation with future distant threats and capabilities has made it questionable, rather than certain, that we could prevail in any conflict in the near future.

It adds little to deterrence to have exotic new weapons on the drawing boards when large numbers of our current planes, tanks, and ships cannot be relied upon today.

We need to improve our combat readiness now. If this means foregoing or deferring the acquisition of costly new systems or additional personnel, then we should make those tough choices. For deterrence, for crises and contingencies in the next few years, and for improved perceptions of America's strength by allies and adversaries, we must turn our existing forces into usable muscle.

When U.S. taxpayers pay for a division or fleet or an air wing, they expect to get a strong and capable unit. And since military funds are necessarily limited by competing requirements for budgetary restraint and for other government programs, our citizens deserve the most cost-effective defense possible.

WHAT CONSTITUTES READINESS?

Readiness is admittedly a somewhat imprecise concept, incorporating both quantitative measures (such as the numbers of personnel and equipment on hand) and qualitative judgments about the ability of men and machines to carry out assigned missions. There is a complicated reporting system described below, but we discovered that commanders have broad discretion in determining their status. One commander, for example, said that he never considered his units "fully trained." Another deliberately downgraded a unit as an incentive to improve. Some commanders report high readiness despite admitted shortages of some people with critical skills and persistent problems with certain kinds of less essential equipment.

Omitted from the specified readiness factors is one which is probably the most important but the hardest to determine—morale. Within broad limits, high morale can make an effective fighting force of a unit which otherwise is undermanned or undersupplied. Similarly, low morale can soften the punch of the best-equipped unit. In fact, of course, high morale and high states of readiness generally go together. Units that have adequate numbers of quality personnel and equipment are usually better able to train and conduct exercises that build cohesive combat forces. When men are overworked with maintenance of inferior equipment, however, or cannot obtain sufficient spare parts or operating hours, they lose interest and job satisfaction. It may be significant in this regard that commanders who reported the most complaints from subordinate personnel on issues like the perceived "erosion of benefits" happened to head units which had serious readiness problems, thus indicating another possible link between low readiness and low morale and perhaps poor leadership.

Improving readiness is not a one-shot goal. Rather, it requires a sustained effort of building inventories, improving equipment, retaining skilled personnel, and raising mo-

rale. These tasks go together and take time. But the single most important change is a simple one of perspective: to give combat readiness a high priority and constant attention.

If senior commanders and service budgets are preoccupied with designing or buying newer weapons, rather than having today's forces ready to perform their missions, the Services will respond to and reflect those priorities. On the other hand, if readiness is the touchstone for pride and confidence in our military capability and is recognized as a priority before the acquisition of new weapons systems, readiness will improve and will remain high.

COMBAT READINESS REPORTING SYSTEMS

Active military units are required to report regularly on their combat readiness in accordance with an elaborate system. While there are variations among the Services in the kinds of information reported and the precise definitions used, the reports generally consist of an overall unit readiness figure, plus figures for personnel readiness, equipment and supplies on hand, equipment readiness, and training readiness. In making determinations for these reports, commanders have some discretion and can add special remarks for further explanation.

Each unit reports a "C-rating" for readiness, both composite and by the four listed categories. C–1 means fully ready to perform its missions; C–2 means substantially ready; C–3, marginally ready; and C–4, not ready. For example, units are C–1 in terms of personnel when they have 95+ percent of their assigned strength (in the Army and Navy; 90+ percent in the Marine Corps and Air Force). They drop to C–4 when their strength is below 75 percent in the Army, 65 percent in the Navy, 70 percent in USMC and Air Force.

When measuring equipment and supplies on hand, the Army and Marine Corps consider 90+ percent of equipment sufficient for C–1 and below 70 percent requiring C–4. The Air Force uses lower rates of 85+ percent and below 55 percent. The Navy rating includes the overall supply situation as well as numbers of aircraft. A further complication is that the Navy reports in terms of mission area readiness as well as overall combat readiness.

A separate rating is given the equipment actually on hand. The Army calls units C–1 when 90+ percent of their equipment is operationally ready and C–4 when that percentage drops below 70 percent. The Marine Corps uses 85+ percent and below 55 percent for the same ratings. In the case of aircraft, the Navy considers units C–1 when they have 75 percent of their aircraft safely flyable and capable of performing assigned missions; they are rated C–4 when the percentage drops below 40 percent. In the Air Force, units are rated C–1 when over 70 percent of their aircraft are operationally ready and C–4 when the figure drops below 40 percent.

Training is another concept about whose very meaning there is no uniformity among the Services. The Army and Marine Corps tie their ratings to time required to bring units to a fully trained status. The Navy has less specific, more judgmental criteria. The Air Force uses the measure of the percentage of trained air crews that are mission ready.

An outside observer finds it hard to understand why there should be such differences among the Services as to what constitutes various degrees of combat readiness. Perhaps a more fundamental problem is whether the wide latitude for local judgment results in comparable and accurate reporting. Although many officers admitted the potential for abuse and inflated reporting, since commanders would likely be reluctant to report a decline in readiness during their command, most officers said that reporting was generally accurate and that readiness is at times even understated rather than exaggerated.

Despite periodic Inspector General visits to check on unit readiness, there is no evidence of any systematic effort to go back and compare actual with reported status, or to revise flitness reports when serious problems are discovered. I believe that oversight procedures should be expanded and strengthened, and that officers should be held accountable for exaggerating the condition of their units.

Military personnel generally have a strong dedication to duty and a "can-do" spirit, despite deficiencies in numbers, training, or equipment. But our men and women in the Services deserve better. There are some indications, for example, that a heavy maintenance load sometimes leads to reduced reenlistment rates. Several commanders reported that they lack adequate numbers of personnel in supervisory enlisted grades. Some shortages in critical skills were attributed to competition from private industry. There is thus an apparent need for a flexible incentive system to attract sufficient personnel in these skills and a requirement for close monitoring of the readiness reporting in the personnel area.

Similarly in training, there must be a close watch on readiness. Many units have reduced exercises in order to cut costs. While no one claimed that these reductions lowered proficiency to an unacceptable level, belt-tightening clearly has its limits. These must be carefully studied so that minimum levels can be recognized and maintained.

Not all units, of course, must be fully combat-ready (C–1) at all times. But persistent shortfalls could lead to situations where mobilization and deployment contingency plans are totally unrealistic and unattainable.

OBSERVATIONS IN THE FIELD

During our visit to a dozen military bases, a fair cross-section of our defense establishment, we found the morale of our volunteer forces surprisingly good despite the problems cited.

Nonetheless, the progress that our nation is making toward achieving a hard-fighting force—ready to meet any situation—is, in my judgment, being seriously and unconscionably impeded by a lack of logistics and maintenance support.

Our national interest requires the most cost-effective defense system we can achieve. It is therefore distressing, for example, to find significant quantities of brand new, highly expensive and sophisticated aircraft inoperable because of shortages of repair parts. These problems plague such aircraft which we examined as the F–14, a $8.7 billion program; the S–3A, a $3.4 billion program; and the F–15, a $12.2 billion program. When we pay such sums for modern weapons, we properly expect that they will be kept combat ready and quickly repairable.

I am also concerned that many of our own forces are working hard and training to fight a well-armed and armored enemy without being given the same modern weapons that we find being sent to many foreign countries under our foreign sales program. This is particularly evident in the case of our latest generation of highly accurate antitank weapons, the TOW and Dragon.

At times it seems that modernization of U.S. forces has been subordinated to a big push to develop new weapons for expanded foreign sales. We are being asked by the Defense Department to believe that a major Soviet buildup in the European theatre has serious implications to our NATO forces, but at the same time we find that in fact the modern weapons to counter such a buildup are being provided to support foreign sales, rather than to supply our own units.

In addition, the sales of these highly sophisticated weapons to these foreign countries must be considered in light of the requirements that such sales might place on our critically skilled manpower capabilities for these systems, as well as the competition on logistics support for these systems.

FORT HOOD, TEX.

The principal readiness issue of the units at Fort Hood is the status of training and logistic material support. Most of the units need additional training to improve their readiness. Yet this division received funds for only 80 percent of the training days which had been requested. We were advised that the constant rotation of units to Europe is causing a problem in stability for training and maintenance. A significant portion of the mechanized equipment, howitzers, and aircraft was below the readiness criteria established at the Corps level. The units at Fort Hood do not have all of the Dragon missile systems that they are authorized. There are other shortages of equipment at Fort Hood, some of which were reportedly created by foreign military sales. Of particular concern were discussions that we had with some of the troops who expressed concern over a shortage of night vision goggles. These troops were concerned that they did not have these goggles but that foreign troops being trained at Fort Hood had these goggles with them. Another concern expressed was with the adequacy of defensive equipment for chemical warfare situations. Helicopter pilots, for example, said that present unwieldy gas masks cannot be used safely by both members of the crew at the same time.

LUKE AIR FORCE BASE, ARIZ.

At Luke Air Force Base, we received a report on the readiness status of the Air Force's newest F–15 aircraft as well as the older F–4 aircraft. At the time of my visit only 23 of the 43 F–15 aircraft at Luke were reported as flyable, with the remainder down either for repairs or supply. We also learned that the unit cost per flying hour of the F–15 is quite a bit higher than that of the F–4 aircraft, and the maintenance man-hours per flying hour were nearly as much as the older F–4 aircraft. Moreover, the F–15 is suffering nearly three times the cannibalization rate of the F–4.

It seems to me that these newer sophisticated systems are demonstrating much higher operating and maintenance costs than the older aircraft that they were intended to replace. During the past year the operational readiness rate for the F–15 aircraft has been consistently lower than the standard established by the Air Force and even lower than the older F–4 aircraft. The Air Force has recently placed many new personnel at Luke who will require significant training to meet qualified skill requirements.

WILLIAMS AIR FORCE BASE, ARIZ.

At Williams Air Force Base, we visited the undergraduate flight training facilities and received briefings on the program being conducted at this location. Many foreign pilots are trained by the Air Force at Williams. The base is operating at this time at only 60 percent of capacity and many trainer aircraft are sitting idle on the runways. Some of the aircraft have been placed in storage at this time. It would appear desirable to explore the possibility of using private contractors for a substantial amount of the training of foreign pilots now being performed by the Air Force.

U.S.S. "CONSTELLATION" AIRCRAFT CARRIER

We observed flight operations of the F–14 aircraft while the carrier was on a training cruise off San Diego. We also discussed the readiness condition of the carrier and visited with the carrier personnel.

The *Constellation* has significantly improved its personnel manning in the past

year to a point where it is now manned to 98 percent of allowance. About 80 percent of the officers and enlisted personnel changed during the latest overhaul, however, thus creating a need for extensive training to reach a proficient degree of readiness. A major problem is the lack of adequate numbers of enlisted personnel for supervisory and training positions (E–4 and E–5 levels) which are necessary to reach a readiness proficiency.

We were concerned to learn that at the time of our visit only three of twenty F–14 pilots on the *Constellation* had ever fired the Phoenix missile, the principal weapon of the F–14 force.

With regard to aircraft readiness, we were told that one-fourth of the F–14s assigned to the *Constellation* were not even aboard because of maintenance requirements. An additional 30 percent of those aircraft aboard were not fully capable. A very serious problem exists with the logistic support of the aircraft on the *Constellation*, particularly with the F–14 aircraft. Over 10 percent of the total maintenance man-hours were consumed in cannibalization of parts from one aircraft to support another. This is a very cosly support procedure. The maintenance crewmen indicate that a much higher percentage of their direct aircraft maintenance goes to perform cannibalization actions. While I am encouraged at the "can-do" attitude of the *Constellation* personnel, I believe that steps to improve the material condition of equipment deserves much higher priority and attention.

NAVAL AIR STATION, NORTH ISLAND, CALIF.

We discussed the readiness of the S–3A aircraft at the Anti-Submarine Warfare Wing headquarters and were seriously concerned to find on two recent completed deployments that this highly expensive and highly sophisticated plane had full system capability only 5 and 6 percent of the time. Current deployments are showing improvement, but such a low rate of readiness for these expensive systems raises serious questions about the quality of our development program.

Despite these problems, I was extremely impressed with the capabilities and determination of our military personnel to operate these highly sophisticated systems.

COMMANDER, NAVAL AIR FORCES—PACIFIC

We visited with the Commander of the Naval Air Forces—Pacific to obtain an overall picture of the readiness of the Pacific Fleet aircraft. Overall, the full systems-capable operational readiness rate of the Pacific fleet aircraft during the years 1974–1976 has averaged between 40 and 45 percent. A major problem again was that cannibalization of aircraft parts consumed over 400,000 man-hours of effort fleetwide between July 1975 and June 1976. This is a tremendous waste of manpower and money and a major indicator of the problems in readines support to these aircraft. Shortages of key supervisory (E–5 to E–9) enlisted personnel in the machinist mate, boiler technician, and boatswain mate skils are a serious concern on the aircraft carriers in the Pacific fleet.

NAVAL AIR REWORK FACILITY—NORTH ISLAND, CALIF.

At North Island we visited the Rework Facility and observed the overhaul and repair efforts being performed on aircraft and helicopters. The workload at this facility is at 80 percent of capability, and it has a payroll of $108 million while employing about 6,800 civilian personnel.

Of particular concern was the shortage of white collar supervisory personnel. It seems that the Wage Board rate increases have been significantly higher than Civil Service pay increases, leading qualified wage board employees to avoid being promoted to white collar supervisory jobs. This issue should be examined further by our Manpower Subcommittee.

1ST MARINE DIVISION—CAMP PENDLETON, CALIF.

We discussed the readiness of the Marine Corps units at Camp Pendleton with the Commander of the 1st Marine Division and visited with units training in field exercises. The major area of concern in the readiness of the 1st Marine Division is the need for more training. The Division appears to be in a period of major buildup after the Vietnam War and from my observations they were "hard at" their training.

The average age of the servicemen in the 1st Marine Division is now only 21 years old, and over 54 percent of the Division troops are 20 years old or younger. The Division also experienced a fine 40 percent first-term reenlistment rate during December 1976.

One major equipment problem was said to be with the M60 machine guns, which have been in short supply and which now are suffering a high failure rate because of cracked receivers. I have since been advised that these problems have been corrected by replacement or repair of defective equipment.

Some enlisted men reported that they had never had an opportunity to fire some equipment assigned to their units, such as flamethrowers and the LAW anti-tank weapon, during the past year. Although the Dragon anti-tank missile is an especially important weapon for an infantry unit such as the 1st Marine Division, this division is not scheduled to receive its allotment until 1978, despite the fact that deliveries have already gone to foreign countries.

MIRAMAR NAVAL AIR STATION—MIRAMAR, CALIF.

We visited the Miramar Naval Air Station to obtain further data on the overall condition of the entire Pacific fleet of F–14 aircraft, F–4 aircraft, and the Navy's E–2B early warning aircraft. We found that the readiness problems observed on the carrier *Constellation* exist fleet-wide—low operational readiness rates and high cannibalization rates caused by logistics problems.

There is a significant contrast between the readiness of the older F–4 aircraft (about 60 percent) and that of the newer F–14s, which have an operational readiness rate of only 30–40 percent and a full systems-capable rate below 30 percent. The Navy needs to decide whether it can afford to acquire and support these much more capable aircraft at an acceptable readiness rate. At present, we are not getting dependable combat power for our huge initial investment in the F–14.

Engine problems have plagued the F–14 for some time and solutions have been slow in coming. The Navy is currently in the second year of a five-year program, costing $552 million, to correct some of these deficiencies by impoving engine and airframe reliability and survivability, by reworking and improving the plane's structure, and by procuring additional spare parts. Even so, there is a widespread belief that a wholly new engine is needed to give the F–14 the capability for which it was designed. Many of these problems might well have been avoided by better initial planning and a more cautious transition from design to procurement.

Again, I have the highest admiration for the pilots and enlisted personnel who are called upon to operate and maintain these highly sophisticated aircraft. Their dedication despite persistent equipment and supply problems is highly commendable.

The E–2B early warning aircraft is one of the highly sophisticated aircraft which is very difficult to maintain in an acceptable readiness condition. Since 1973, this aircraft has registered a full systems-capable readiness rate of between 30 and 41 percent. The Navy plans to replace this aircraft with a more current version, the E–2C, early next year. In view of these past problems, it remains to be seen whether this newer model will provide improved readiness rates.

COMMANDER, NAVAL SURFACE FORCE, PACIFIC FLEET—SAN DIEGO, CALIF.

We visited the Pacific Surface Fleet Commander at San Diego and received an excellent report on the readiness of the surface fleet in the Pacific.

The major problem appears to be from shortages in the enlisted personnel area. We were advised that the supervisory E–5 and E–6 skill levels were less than 50 percent of allowances. The short-based fleet maintenance assistance groups have only 69 percent of their allowed manning and the new DD963 and LHA ships are also low-manned. The fleet is having equipment problems with boilers, air compressors and main feed pumps, which were attributed to less than thorough overhauls in prior years.

The command is taking some innovative steps to improve the ship maintenance problems. These include providing full funding of maintenance parts requirements for shipboard preventive maintenance for selected test ships and in turn extending periods of ship operation between overhaul.

The total force condition was reported at about 50 percent operationally ready, with equipment problems causing the most serious degradation. Among the most significant problems mentioned were the installation of new equipment prior to adequate parts support, higher failure rates than predicted by manufacturers, lack of procurement sources for older equipment and difficulties in getting units repaired.

WARREN AIR FORCE BASE—CHEYENNE, WYO.

We visited Warren Air Force Base to discuss the readiness of the Minuteman III forces, as well as observe directly Minuteman operations in their silos.

Accordingly, we toured a control room of the Minuteman wing and observed the operations and controls of our Minuteman missiles. We also had the opportunity to inspect a Minuteman silo and the missile in place.

The Minuteman force which we observed was in as good a readiness condition as possible given the fact that the missiles have never been test fired from site locations. We should, of course, expect peak readiness in our strategic nuclear forces.

STRATEGIC AIR COMMAND HEADQUARTERS—OMAHA, NEBR.

We visited the SAC headquarters to discuss the readiness of our strategic forces and observe the headquarters control of those forces.

In addition, we were briefed on the overall targeting plans and capabilities of our strategic forces and inspected the major control operations of the Strategic Air Command. Much of the discussion was of a classified nature, but the visit was extremely useful to us in obtaining a greater insight into the strategic issues which we will be considering in the months ahead.

RECOMMENDATIONS

In addition to particular observations and specific suggestions related to the bases visited, there are several general recommendations which apply to all services and should help to improve overall readiness.

1. The Defense Department should assign a higher priority to achieving improved readiness and should monitor changes in readiness indicators more closely. Reports to senior officials and to Congress should be systematized and made regularly, such as quarterly, and in sufficient detail and appropriate format so as to highlight problem areas. In addition to unit readiness, the Services should report on system readiness of those items which exhibit serious or persistent problems of manning, maintenance, or

supply. One specific goal should be to reduce the cannibalization rate for aircraft parts.

2. In order to free funds and personnel to concentrate on improving readiness, the Services should slow down their purchases of new equipment until they "get well" in terms of readiness. Special reviews should be conducted of existing equipment and components which are not functioning as planned in order to determine those which are not cost-effective or essential to mission performance.

3. The President should declare a clear policy of no diversions of critically needed supplies to Foreign Military Sales unless and until U.S. forces have achieved adequate readiness with respect to those items. The current problem is not only that some foreign purchasers receive equipment prior to U.S. units, but also that skilled contractor personnel are sent abroad to help recipients utilize the equipment.

4. The Defense Department should re-evaluate current standards of proficiency in view of reduced opportunities for training exercises, flight hours, and live-firings of weapons. Where proficiency has been maintained, curricula and training schedules should be altered; but where proficiency has been seriously degraded, minimum standards should be proposed and cost-saving alternatives such as the use of simulators and other training aids should be exploited.

5. The Department of Defense should strengthen its consideration of the reliability and maintainability aspects of new weapons in several ways.

a. Testing and evaluation of new weapons should be done in a manner that is realistic to operational conditions rather than to a laboratory environment.

b. The Department should more closely review the promises that are made by contractors about these features when new programs are undertaken and should insist on appropriate penalties as well as bonuses, depending upon demonstrated performance. If, because of technological difficulties, the preferred readiness criteria cannot be met with the planned levels of reliability and maintainability, the Congress should be so advised prior to the start of production.

c. The Department should also reevaluate the actual results of recent weapon systems in terms of maintability and reliability, comparing these results to the promised specifications or goals at the start of the program. If it is determined that acceptable readiness criteria cannot be reached within a reasonable time, the consequences for meeting operational commitments should be transmitted to the Committee. We need to be assured before entering into production that new weapons are as reliable and efficiently maintainable as technology permits and as high unit costs demand.

d. In order to make these analyses, the Department will have to develop careful ways of measuring the costs and benefits of increasing sophistication in weaponry over its life-cycle so that we can be assured that our true fighting capability improves commensurately as we rely ever more on advanced technology.

POSTCRIPT: MARCH 30, 1977

While this report was in the final stages of preparation, two developments occurred which deserve special mention.

First, President Carter chose, in his budget amendments, to increase funds requested for readiness by $605 million and to slow down the production of some weapons which have been experiencing readiness problems. Though I plan to review these proposals carefully, I welcome this concrete evidence of the higher priority now placed on improving readiness.

Second, I have become aware of a study of U.S. Army unit readiness reporting completed last spring by a group of officers at the Army War College. This study, based upon an extensive worldwide survey, confirms my own concerns about the reporting system. The study concluded that the Army unit readiness reporting system has a "poor reputation for accuracy and validity"; that "optimistic reporting masks critical problems"; that units "peak" for regular reporting dates at the cost of "inefficiencies involving untold wasted man-hours"; and that reporting lacks a system of independent checks which could improve the situation. It is imperative that the Army take expeditious action to correct these problems and that other Services also give this problem close scrutiny with overall supervision and guidance from the Secretary of Defense.

ATTACHMENT 1: MILITARY INSTALLATIONS VISITED

Offut Air Force Base, Nebraska—Strategic Air Command Headquarters.

Fort Hood, Texas—1st Cavalry Division, 2nd Army Division.

Luke Air Force Base, Arizona—Tactical Fighter Training Wing.

Williams Air Force Base, Arizona—Undergraduate Flying Training Wing.

USS Constellation, San Diego, California—Naval Aircraft Carrier.

Camp Pendleton, California—1st Marine Division.

Naval Air Station, Miramar, California—F-14, F-4 Aircraft.

Naval Air Station, North Island, California—S-3A Aircraft.

Naval Air Research Facilities, North Island, California—Repair and Maintenance.

Commander, Naval Aircraft Pacific, San Diego, California—Pacific Fleet Aircraft Readiness.

Commander, Naval Surface Vessels Pacific, San Diego, California—Pacific Fleet Ship Readiness.

Warren Air Force Base, Cheyenne, Wyoming—Minuteman III Missile.

PREVENTIVE CARDIOLOGY PROGRAMS

Mr. PERCY. Mr. President, numerous studies have been made in recent years of heart disease, our Nation's No. 1 killer. Most attention is given to major research projects and medical breakthroughs. But equally essential is the implementation of prevention methods by every American through his or her diet and exercise. One of the most commendable developments in preventive cardiac care is the involvement of private industries in employee health programs.

There are over 150 companies in the Chicago area alone which offer preventive cardiology programs for their employees. I would like to particularly bring to the attention of my colleagues and the public Standard Oil's medical and environmental health services program run under the directorship of Dr. Peter Wolkonsky.

I ask unanimous consent that the following articles on Dr. Wolkonsky's and Standard Oil's innovative and human pioneering of private industries concern for the health of its employees be printed in the RECORD: "Comprehensive Medicine in Industry," from the bulletin of the University of Chicago Medical School and "Heartwatch on Standard Oil Brass," from the Chicago Tribune be printed in the RECORD.

There being no objection, the material was ordered to be printed in the RECORD, as follows:

[From the Chicago Tribune, Mar. 27, 1976]

A TREADMILL TO FITNESS: HEARTWATCH ON STANDARD OIL BRASS

Top executives at Standard Oil's towering headquarters building on Michigan Avenue are kept in physical condition under one of the more advanced industrial health programs in the nation. In charge of the program is Dr. Peter Wolkonsky, the company's medical director, who observes that every year, "between one and three of our people died of heart attacks at their desks."

As a preventive measure, employes are treated in a cardiac fitness laboratory on the 38th floor. It is equipped with testing and rehabilitation equipment arranged in 12 exercise stations with skip ropes, a punching bag, parallel bars, treadmill and rowing machine.

Lunch hours find the executives crowding into the lab, because, as Dr. Wolkonsky points out, many "feel themselves too busy during the working day to devote an hour to the program."

[From "Medicine on the Midway," bulletin of University of Chicago Medical School, Spring Issue, 1975]

COMPREHENSIVE MEDICINE IN INDUSTRY

Aside from its bright red color, the emergency hot-line on the 38th floor of the Standard Oil Building looks like any other telephone. But it is not just another phone. It brings messages of distress to Standard's medical department. When it rings, specialists rush to the cardio-pulmonary-resuscitation cart and set the stop clock. They are ready to handle whatever problem awaits them.

The clock tells them exactly how much time elapses between their receipt of the emergency call and the moment they reach the patient's side. For instance, they have to minister to a cardiac arrest victim within five minutes.

After that, it's likely to be too late. They can be anywhere in the 80-floor building within two and one half minutes. When the red phone sounds, freight elevator 41 (the only one in the building that goes from the top floor to the bottom) automatically cancels all other calls and proceeds directly to the 38th floor.

The emergency cart is equipped with defibrillators, an EKG machine, oxygen masks, external massage, aspirator, drugs and other survival paraphernalia. It is used from three to ten times a month but fortunately has not yet been required for its main intended purpose, the treatment of cardiac emergencies.

This emergency procedure is just one of many aspects of the comprehensive Medical and Environmental Health Services program of the Standard Oil Company (Indiana), under the director of Dr. Peter Wolkonsky. While the medical department is well equipped to handle emergencies, it is geared toward preventing them.

"We want to help our employees to stay alive and productive," Dr. Wolkonsky says. "We practice preventive medicine."

Periodic examinations are the mainstay of the medical program. A thorough medical history is taken. An internist examines the employee, who then goes through a battery of vision audiometer, x-ray, pulmonary function, blood chemistries, electrocardiograph, and other diagnostic tests. If necessary, other indicated medical tests may also be given. "We are looking for everything from gout to cancer," Dr. Wolkonsky says. "These examinations very often uncover problems which the patient did not know he had, and which can be treated. The employee can then arrange to get the proper treatment for his disorder."

23 Dec 1975
2 JAN 1976

NEEDED IMPROVEMENTS IN AUTOMATIC TEST EQUIPMENT (ATE) DEVELOPMENT AND ACQUISITION

TO: AFSC/CC (GENERAL EVANS) AFLC/CC (GENERAL ROGERS)

1. CURRENT PROBLEMS WITH F-15 ATE LEAD ME TO CONCLUDE THAT WE NEED TO IMPROVE OUR ATE DEVELOPMENT AND ACQUISITION MANAGEMENT PROCEDURES. I AM CONVINCED THAT A HISTORICAL REVIEW OF ATE ACQUISITION AND PERFORMANCE, WOULD SHOW THAT FEW OF OUR CURRENT PROBLEMS ARE NEW. YET, OUR APPROACH TO ATE DEVELOPMENT AND ACQUISITION MANAGEMENT ESSENTIALLY REMAINS UNVARIED, AND LESS THAN SATISFACTORY RESULTS HAVE BEEN ACHIEVED. I BELIEVE THE PRINCIPAL PROBLEM IS THAT ATE HAS BEEN VIEWED BY THE SPO AS JUST ANOTHER PIECE OF AEROSPACE GROUND EQUIPMENT. NOT BEING AN INTEGRAL PART OF THE WEAPON SYSTEM, IT HAS OFTEN BEEN GIVEN INADEQUATE ATTENTION BY EITHER THE CONTRACTOR OR THE SPO UNTIL IT IS TOO LATE. WITH NO CORPORATE MEMORY OF LESSONS LEARNED, EACH SPO HAS REINVENTED BOTH THE PROBLEM AND SOLUTION.

2. IN LIGHT OF THE SUBSTANTIAL CONTINUING INVESTMENT IN ATE, AND THE CRITICAL SUPPORT PROBLEMS THIS EQUIPMENT CONTINUES TO PRESENT, I BELIEVE ATE DEVELOPMENT AND ACQUISITION MUST BE GIVEN MORE CENTRAL MANAGEMENT. I WOULD LIKE YOUR VIEWS ON ESTABLISHING AN AFSC ORGANIZATION - PERHAPS AT ASD - AND JOINTLY MANNED BY AFSC AND AFLC TO ACHIEVE THAT CENTRALIZATION AS SOON AS POSSIBLE. I ENVISION A CENTRAL OFFICE FUNCTIONING AS THE PRINCIPAL DEVELOPMENT AND ACQUISITION MANAGERS FOR ATE AND

A-8/D-8

CONT'D

RELATED ITEMS, POSSIBLY EXPANDING LATER TO ENCOMPASS ALL SUPPORT EQUIPMENT. IT WOULD BE THE RESPOSITORY OF THE CORPORATE MEMORY FOR ATE LESSONS LEARNED, AND THE PLANNING ACTIVITY FOR FUTURE USE OF OFF-LINE ATE AT ALL LEVELS OF MAINTENANCE. THIS OFFICE WOULD NOT USURP THE SPD PREROGATIVES, BUT ON THE OTHER HAND I DO NOT ENVISION THE INDIVIDUAL PROGRAM OFFICES BEING PERMITTED TO PROCEED WITH THE DEVELOPMENT OF NEW PECULIAR ATE WITHOUT THE ADVICE AND COORDINATION OF THE ATE OFFICE. I FEEL THAT PAST PERFORMANCE NECESSITATES A DIFFERENT APPROACH TO THE SOLUTION OF THIS PROBLEM. YOUR IDEAS WILL AID ME IN ITS TIMELY IMPLEMENTATION.

DAVID C. JONES, GENERAL, USAF
CHIEF OF STAFF

Polmar speaks on Soviet Navy

Speaking to three full-house audiences at NOSC recently, Norman Polmar discussed the Soviet naval threat.

Polmar, editor of the U.S. Navy section of **Jane's Fighting Ships** from 1966 to 1976, discussed the Soviet navy as an instrument of national policy.

In addition to their role as combatants, he said, "the Soviets use their ships on a day-to-day basis for political presence and confrontation.

"To be effective in these roles, the ships must be impressive to potential adversaries, and they are," Polmar said.

He cited as an example the "Kashin" class guided missile destroyers, which with speeds of 36-37 knots are the world's fastest ocean-going ships.

The ships are powered by gas turbine engines and first went to sea in the winter of 1962-63. In contrast, the U.S. Navy's first gas turbine ship, USS Spruance (DD-963), went to sea in 1975.

Polmar also discussed the Soviets' first aircraft carrier, Kiev. The 925-foot-long, 36,000-ton displacement ship is the largest ship build by the Soviet Union, he said.

Kiev, which has no catapults or arresting cables, carries YAK-36 Forger V/STOL aircraft and helicopters.

Why are the Soviets building carriers?

"The USSR has watched carrier numbers steadily declining in the fleets of the U.S. and its allies," he said. "Kiev, with its 35-40 V/STOL aircraft, can be in the right place at the right time to get control of a situation."

Main threat

The Soviets' main navy threat, Polmar said, consists of its submarine fleet and its aircraft, particularly the nearly 300 Badger medium-range bombers.

The Soviet sub fleet includes 340 boats, about three times as many as the U.S. fleet. Additionally, since the mid-60's, the number of U.S. yards building nuclear submarines has declined from seven to two, while Soviet yards have grown from two to five, putting out three times as many boats annually as the U.S.

Polmar cited Soviet development of guided missile capabilities for submarines, including the Shaddock (SSN-3), a 250-nautical mile range missile carried by about 30 "Echo" class submarines.(It is also carried by four other classes of subs, and by "Kynda" and "Kresta 1" class cruisers.)

Although the missiles must be surface-launched by the subs, the "Charlie" class submarines each carry 8 SSN-7 cruise missiles with 30-nautical mile range that can be launched underwater.

Polmar noted that Soviet Fleet Ballistic Missile submarines carry about 800 strategic missiles, compared to about 650 carried on U.S. FBM subs.

Included in the Soviet fleet are 33 "Yankee" class boats, each carrying 16 SSN-6 missiles with ranges of more than 1,000 nautical miles, and ten Delta I and II class submarines. The latter carry 12 or 16 SSN-8 missiles with ranges of about 4,500 nautical miles.

A Delta submarine sitting at Murmansk can target all of the northern portion of the U.S., in an arc extending south almost to San Diego, Polmar said.

He said target detection for the Soviet FBM subs is done by long-range Bear and medium-range Badger aircraft, and by two satellites employed for ocean surveillance.

Other fleets

Polmar also discussed the other ocean-going Soviet fleets:

1) the oceanographic research and intelligence collection fleets. The former is the largest such fleet in the world dedicated to collection of scientific data about the oceans, and there are about 50 dedicated intelligence collection ships (AGI's) in the Soviet navy.

2) space tracking fleet, consisting of about 50 ships used to track space shots. (The U.S., Polmar noted, uses land-based tracking facilities because it has allies around the world where these facilities can be located.) These ships are also used for political "presence," especially in Third World countries, as a demonstration of advanced Soviet technology.

3) merchant fleet. The Soviet merchant fleet ranks either first of second in number of vessels and first in total tonnage, compared to U.S. rankings of sixth or seventh and eighth to tenth in the same categories.

"The year 1972 was the critical year in which the U.S., a sea power, was overtaken in tonnage by the Soviet Union, a land power," Polmar said. He noted the U.S. merchant fleet concentrates on building container ships, requiring special on/off-loading facilities available only at major ports, few of which exist in Third World countries.

The Soviet fleet builds large numbers of roll-on/roll-off ships, which do not require any special facilities. Not only are they useful for cargo, he said, but they also have special heavy-duty deck plating that allows them to carry tanks.

4) fishing fleet, also the largest in the world, which combines trawlers; mother ships that clean, filet, can and pack the fish, and refrigerator ships that carry the fish from the fishing grounds directly to market.

People key element

In concluding his presentation, Polmar said, "The key element in any navy, theirs as well as our own, is the people. Soviet sailors are intelligent and highly motivated, and very well trained.

"Their officers are also intelligent and highly motivated. Most of them are sons or grandsons of naval officers, or party members. One hundred per cent are college graduates; half of them have completed post-graduate studies, many up to Ph.D.'s in naval science."

Polmar noted the "increasing professionalism" of Soviet navymen (There are no Soviet counterparts to U.S. Navywomen), and concluded, "We find too many of the curves, too many of the key points, shifting to the Soviet side of the ledger."

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